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FOR

**Method and Apparatus
for Graphical Device Management
Using a Virtual Console**

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for Graphical Device Management
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BACKGROUND OF THE INVENTION

5 1. Field of the Invention

The present invention relates generally to software for developing graphical device management applications for managing remote devices. More specifically, the present invention relates to technology that enables the rapid development of graphical user interfaces for remote devices through the use of a virtual console.

10 2. Background Information

As computer networks continue to grow at a rapid pace, it is not uncommon for the networks to span organizational and geographical boundaries forming enterprise networks. Many of the enterprise network and computer devices upon which the network relies, such as switches, routers, bridges, hubs, and gateways, must often be remotely configured in order to effectively manage the network.

15 The present generation of many networking and computing devices supports both local and remote methods of configuration. For example, the use of a locally connected terminal to configure a device using a console user interface (CUI) to the device's serial console is very common. At the same time the use of a remotely
20 connected workstation with a graphical user interface (GUI) to configure the same device is also an expected device management product feature. Though running on different platforms, both the CUI and GUI must use the same predefined command set to update the configuration file. Regardless of the method used, the ultimate
25 purpose is to refresh the state of the remote device's configuration kernel (CK) by means of a configuration file. The CK includes all the variables, data structures and functions whose purpose is to maintain the state of the configuration of the device

(e.g. user names, passwords, timeout values, etc.). The configuration file is an ASCII flat file that contains configuration commands used to refresh the CK.

One issue for programmers developing and maintaining device management application software is the redundancy and duplication of effort needed to maintain and support both the local and remote methods of device configuration. To a certain degree the remote GUI developer must code the same intelligence for providing configuration functionality as does the local CUI developer. Although the CUI and GUI user interfaces will differ, the underlying requirements of the command set necessary to update the configuration file will be the same. Consequently, the GUI developer ends up having to maintain command set aware source code that duplicates the functions of the CUI firmware implemented in the remote device's serial console.

One solution to eliminating the redundancy would be to port the CUI to the remote platform used to remotely manage and configure devices. However, the CUI is often implemented in firmware that cannot easily run on a non-native platform such as that running a typical device management system GUI. For example, not all variables required for the operation of the console firmware are able to be resolved in a non-native remote platform. Consequently, most software developers employ a brute force approach in the development of GUI applications for remote device management.

The brute force approach such as that used by previous versions of the Shiva Virtual Private Networking (VPN) Manager, one component of a suite of graphical network management applications from Intel Corporation, the assignee of the present invention, is illustrated in **Figure 1**. First, the configuration file is downloaded from the remote device **110** into the GUI application. Then, the user modifies the configuration file using the GUI application **120**. Finally, the process is

reversed by uploading the modified configuration file back to the remote device 130. The modified configuration file then refreshes the state of the CK with configuration changes that reflect the user modifications.

This approach has several drawbacks, not the least of which is the requirement of associating each command parsed from the configuration file with the appropriate graphical component of the GUI application. The number of different graphical components that can be employed in a typical GUI application is enormous. A significant amount of intelligence must be coded in the GUI to associate all the configuration commands parsed from the downloaded configuration file with their corresponding graphical components. Typically, an elaborate routine is required to populate the graphical components based on the downloaded and parsed configuration commands, and a similarly elaborate routine is required to reconstruct the configuration commands for upload based on the graphical components' contents. Intricate validation mechanisms must be employed to ensure that the commands uploaded back to the remote device contain no illegal parameters. Moreover, it is likely that interdependencies between certain commands would further complicate the validation mechanisms.

In order to keep up with the rapid pace of remote computer and networking device management technology, it is clear that new approach for developing graphical device management applications is needed. An approach that facilitates the rapid development and maintenance of GUI applications for remote device management is therefore desirable, not only to eliminate the redundancy currently involved in maintaining multiple methods of updating device configurations, but also to reduce the complexity. One approach is the integration of the CUI and GUI interfaces in a user-friendly way – an approach that presents a unique set of challenges, requiring a new and novel solution.

SUMMARY

According to one aspect of the invention, a method for developing a graphical device management application is provided for creating a graphical component using a graphical programming language and associating the graphical component with a device configuration command. The method further provides for linking the associated graphical component with a console user interface (CUI) and a configuration kernal (CK). Both the CUI and CK have code for configuring a remote device according the device configuration command. Finally, the method provides for building a graphical user interface (GUI) from the linked graphical component, the CUI and the CK.

BRIEF DESCRIPTION OF DRAWINGS

The present invention will be described by way of exemplary embodiments, but not limitations, illustrated in the accompanying drawings in which like references denote similar elements, and in which:

Figure 1 illustrates a block diagram of the prior art device management process;

Figure 2 illustrates a block diagram of the relationship of the GUI, CUI, and CK of the present invention in accordance with one embodiment;

Figure 3 illustrates a block diagram of refreshing the state of the GUI in response to messages sent from the CUI in accordance with one embodiment of the present invention;

Figure 4 illustrates a block diagram of sending messages to the CUI in response to user actions in the GUI in accordance with one embodiment of the present invention; and

Figure 5 illustrates a general-purpose computer system upon which an embodiment of the present invention may be implemented.

DETAILED DESCRIPTION OF THE INVENTION

In the following description various aspects of the present invention, a method and apparatus for graphical device management using a virtual console (hereinafter “GDMVC”), will be described. Specific details will be set forth in order to provide a thorough understanding of the present invention. However, it will be apparent to those skilled in the art that the present invention may be practiced with only some or all of the described aspects of the present invention, and with or without some or all of the specific details. In some instances, well known features may be omitted or simplified in order not to obscure the present invention.

Various operations will be described as multiple discrete steps performed in turn in a manner that is most helpful in understanding the present invention. However, the order of description should not be construed as to imply that these operations are necessarily performed in the order they are presented, or even order dependent. Lastly, repeated usage of the phrase “in one embodiment” does not necessarily refer to the same embodiment, although it may.

Referring now to **Figure 2**, wherein a block diagram illustrating the relationship of the GUI, CUI, and CK of the GDMVC method and apparatus in accordance with one embodiment is shown. As illustrated, the GUI **210** and CUI **220** form a self-contained application, with the CUI **220** running under the GUI **210**. Since the CUI **220** is not running on an actual remote device, as in the prior art device management systems, it is referred to as a virtual console, hence the name of the present invention. The use of a virtual console avoids the difficulties inherent in attempting to interact directly with the remote device’s CUI, such as latency problems (i.e. delays in refreshing the contents of the CK), and resource contention

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(i.e. when more than one user attempts to update the configuration at the same time, thereby creating a potential lockout situation).

Rather than recreating command set aware source code in the GUI **210** to handle each of the configuration commands as is done in the prior art “brute force” approach, the method and apparatus of the present invention re-uses the CUI firmware code and underlying CK. In one embodiment, the re-used CUI code is linked with the GUI code as a library. The interaction between the GUI **210** and the “virtual” CUI **220** (i.e. the CUI running the re-used CUI code and underlying CK) is performed in a standardized manner. In one embodiment the standardization of the interaction is implemented through the use of a set of object-oriented classes and macros.

With reference to **Figure 2**, the standardized manner of interaction between the GUI **210**, CUI **220**, and CK **230** can be summarized as

- 1) refreshing the GUI **210** with any change in state of the CK **230** in response to messages sent from the CUI **220** (**240**); and
- 2) sending messages to the CUI **220** in response to user actions in the GUI **210** and updating the corresponding state of the CK **230** (**250**).

In operation, a file containing all of the console commands that define the device’s configuration is downloaded and passed to the CUI **220** running under the GUI **210**, thereby initializing the state of the CK **230**. The user can then use the facilities of the GUI **210** to make modifications to the device configuration, during which the GUI **210** invokes the facilities of the re-used CUI code and the underlying CK **230**. Once the modifications are complete, the device’s configuration is uploaded back to the remote device to refresh the state of the remote device’s CK **230**.

An advantage to implementing the GUI 210 as encapsulating the CUI 220 as a virtual console is that the coding necessary to associate configuration commands with the GUI's graphical components is substantially reduced and does not require detailed intelligence about the configuration command set's behavior. A typical GUI application might employ a combination of tree views, list views and various dialogs to represent a configuration device. For example, a command in the configuration file might be:

Hostname MyHost

The Hostname command might be directly associated with an edit control in dialog, e.g. a dialog implemented in Visual Basic or other graphical programming language.

Using the prior art brute force approach requires that command set aware GUI code must be written to parse the command from the downloaded configuration file and then to populate the edit control with the text MyHost. The user could change the contents of the edit control, which would then be written with the hostname command to a updated configuration file by the GUI application. This process must be repeated for each individual configuration command and associated graphical component. Eventually, after completing all the changes, the updated configuration file would be uploaded back to the remote device, which in turn refreshes the state of the remote device's CK.

Using the facilities of the present invention in one embodiment, implementing the association between the hostname command and the corresponding edit control is accomplished much more efficiently than the brute force approach using the following macro:

ASSOCIATE_COMMAND (CCmdEdit, hostname)

In the macro, the first parameter is the class of the instantiated object bound to the edit control. The second parameter is the command keyword. Commands

associated with other types of controls would require other control classes to be instantiated. For example, the class for a checkbox control might be CcmdCheck. For each command, a similar line of code is all that is needed to associate the command with its corresponding control.

5 The use of the macro provides one example of a tool for interacting between the GUI **210** and CUI **220** in a standardized manner. Implicit in the macro usage is that the configuration commands used by the remote CUI are already in a standard format, typically a keyword followed by one or more parameters.

10 Once the GUI **210** communicates to the CUI **220** the contents of the command, then the CUI **220** updates the CK **230** and reconstructs the configuration file from the state of the CK **230**. If the command sent by the GUI **210** to the CUI **220** is invalid, an error message is sent back to the GUI **210** for display to the user.

15 In one embodiment, the interaction between the GUI **210** and CUI **220** is implemented in the CUI **220** with a function having an interface similar to that of the following C prototype:

```
BOOL SendCommand(const char* lpszCmd, char* lpszMsg,  
                                                         int nMsg);
```

where

lpszCmd is a pointer to the command string passed to the CUI **220**;

20 lpszMsg is a pointer to a buffer containing any reply text from the CUI **220**,

and

nMsg is the size of the buffer pointed to by lpszMsg.

25 The following paragraphs describe the interaction between the GUI **210** and the CUI **220** in a standardized manner in further detail.

Referring now to **Figure 3**, wherein a block diagram illustrating the standardized manner of refreshing the GUI **210** to reflect the state of the CK **230** as communicated by the CUI **220** is shown in accordance with one embodiment of the present invention. The standardized manner of refreshing the GUI **210** is employed whether the GUI **210** is being initialized following a download of a device's configuration, or whether the GUI **210** is being refreshed after the user has caused changes in the CK **230**. The process involves interrogation **310** of the CUI **220** for a list of all of the device's configuration commands (i.e. the commands that describe the state of the CK), enumerating all of the commands in the list, and instantiating **360** and initializing **365** a graphical component for each command by comparing each command in the list to a comprehensive register of commands that identifies each command's associated graphical component.

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As shown, in one embodiment the latter two steps are accomplished by looping through the command list one at a time until the end of the list is reached. Specifically, the process involves seeking to the first command in the list **315**, and if the end of the list has not yet been reached **320**, then seeking again to the first registered command **330**. Once a matching registered command is found **345** the associated graphical component is identified **355**. If an instance of the associated graphical component does not yet exist, then one is first instantiated **360** and then initialized **365**. Otherwise, the existing instance of the associated graphical component is simply initialized **365**. This process is repeated by seeking to the next command in the list **340** until the list is exhausted **325**. In another embodiment, an alternative method of comparing the list of commands to the command register is performed using a randomly accessible data repository for the comprehensive command register and associated graphical component and using a direct lookup by a command identifier, thereby eliminating the need for the looping logic.

The interrogation **310** is accomplished by sending a command to the CUI **220**. As an example, in one embodiment the command could be
`show config`

This command is passed in the `lpszCmd` parameter to the `SendCommand` call
5 prototype previously described. In return, the CUI **220** returns the list of commands in the `lpszMsg` parameter.

Initialization **365** of a graphical component for a command also involves interaction in a standardized manner between the GUI **210** and the CUI **220**. In one embodiment, the interaction employs a common mechanism used by the CUI **220** to
10 supply help text for a given command in the command set, i.e. passing the command to the CUI **220** followed by the “?” symbol. As an example, if the `CCmdEdit` class initialization code calls the `SendCommand` prototype previously described with the string “hostname ?” in the `lpszCmd` parameter, then the CUI **220** returns the text “<name> (Max length=8)” in the `lpszMsg` parameter. The
15 initialization code then parses this information and sets the edit control to accept a maximum of 8 characters. Thus, an edit control with a spin button that accepts only numbers would be initialized with meaningful minimum and maximum values as provided in the associated command’s help text. Of course, this method of initialization of a graphical component will only work for commands where the format
20 of the returned text is itself standardized in the CUI **220**, as in the case of the returned text of the help command.

Referring now to **Figure 4**, wherein a block diagram illustrating the standardized manner of sending messages to the CUI **220** to update the CK **230** in response to user actions in the GUI **210** is shown in accordance with one
25 embodiment of the present invention. The standardized manner of updating the CK **230** is invoked when the user completes a modification of a given graphical

component. This typically occurs when the user has finished typing in the new value in the graphical component (e.g. the edit control) which then loses the input focus (i.e. when the user selects another control from the display or leaves the dialog).

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5 With reference to **Figure 4**, the first step in the process is to send **410** the configuration command associated with the graphical component to the CUI **220**. In one embodiment this is accomplished by sending the command string representing the command to the CUI **220** using the C prototype SendCommand and the TpszCmd pointer. If the CUI **220** replies with an error message, the text of that message is returned **420** to the GUI **210** using the TpszMSG pointer of
10 SendCommand. The GUI **210** displays the error message to the user **430** and any graphical component-specific recovery from the error is performed **440**. For example, in the case of a configuration command associated with an edit control graphical component, the GUI **210** sets the input focus back to that edit control so that the user can correct the error. If the CUI **220** detects no error, the CUI **220** next
15 determines whether the configuration command sent by the GUI **210** is interdependent with any other configuration commands **450**. If so, the GUI **210** is refreshed using the standardized manner of refreshing the GUI **300** described in **Figure 3** to reflect any changes in the CK **230** that may have resulted from the interdependencies.

20 The use of a virtual console to provide a remote graphical device management application not only reduces the redundancy inherent in the prior art by reusing the remote device's CUI and CK code, but also reduces the programmer's task in developing a GUI to one that is almost trivial. Using the method and apparatus of the present invention, all the programmer needs to do to add a new
25 configuration command to the GUI is 1) add a control to a dialog template, using the facilities of the graphical programming language (e.g. Visual Basic), 2) create a

macro to associate the control with the new command, and 3) rebuild the GUI application using the latest version of the reused CUI and CK code libraries.

This virtual console approach can be used in the development of remote management tools for any computer or networking device that has a console interface, and whose CUI and CK code can be extracted for re-use. Even for
5 devices without a console interface, the virtual console approach might still be feasible if a CUI could be created to encapsulate the existing CK code.

Additional advantages to the virtual console approach to graphical device management includes the enforcement of consistency in the use of the remote
10 device's command set, and the promotion of a normalized format for console help text. The close correspondence of the graphical components of the GUI with the console commands of the CUI provides a more standardized and user-friendly interface.

Referring now to **Figure 5**, wherein a block diagram of a general-purpose computer system upon which an embodiment of the present invention may be
15 implemented is shown. As illustrated, general-purpose computer system **500** comprises a bus **501**, or other communications hardware and software, for communicating information, and a processor **502** coupled with bus **501** for processing information. Computer system **500** further comprises a random access
20 memory (RAM) or other dynamic storage device **502** (referred to as main memory), coupled to bus **501** for storing information and instructions to be executed by processor **502**. Computer system **500** also comprises a read only memory (ROM) **503**, and/or other static storage device, coupled to bus **501** for storing static
25 information and instructions for processor **502**. Mass storage device **504** is coupled to bus **501** for storing information and instructions.

Furthermore, mass storage device **504**, such as a magnetic disk or optical disk, and its corresponding disk drive, can be coupled to computer system **500**. Computer system **500** can also be coupled via bus **501** to a display device **521** for displaying information to a computer user such as a network manager. Display device **521** is used to display windows containing the graphical user interface to the remote device management application. Display device **521** can include a frame buffer, specialized graphics rendering devices, a cathode ray tube (CRT), and/or flat pane display. An alphanumeric input device **522**, including alphanumeric and other keys, is typically coupled to bus **501** for communicating information and command selections to processor **505**. Another type of user input device is cursor control device **523**, such as a mouse, a trackball, a pen, a touch screen, or cursor direction keys for communicating direction information and command selections to processor **505**, and for controlling cursor movement on display device **521**. This input device typically has two degrees of freedom in two axes, a first axis (e.g., the x-axis) and a second axis (e.g., the y-axis), which allows the device to specify positions in a plane. However, this invention should not be limited to input devices with only two degrees of freedom.

Another device that may be coupled to bus **501** is a hard copy device **524** which may be used for printing instructions, data, or other information on a medium such as paper, film, or similar types of media. Additionally, computer system **500** can be coupled to a device for sound recording, and/or playback **525**, such as an audio digitizer coupled to a microphone for recording information. Further, the device may include a speaker that is coupled to a digital to analog (D/A) converter for playing back the digitized sounds.

Network interface card **526** is coupled to bus **501**. Network interface card **526** is further coupled to an external computer network (not shown). Network

interface card **526**, in conjunction with appropriate data communications protocols (e.g., the TCP/IP suite of internetworking protocols), provide the means by which a graphical device management application operating on a general-purpose computer system **500** exchanges information with other devices coupled to the same

5 computer network. Modem **527** is coupled to bus **501**, and provides an alternate means of exchanging information with other devices for which a modem connection to an external computer network or device (not shown) can be established.

Computer system **500** and GDMVC application software stored and executed therein as part of the GDMVC method and apparatus operate in conjunction with an

10 operating system with graphics capability, such as Microsoft's Windows operating system. Commercially available computer systems implementing the features of general-purpose computer system **500** include a broad range of operating system-based computers, including server computers, desktop computers, workstations, devices, or appliances. Furthermore, the present invention may be used in

15 conjunction with various browser (e.g. Microsoft Internet Explorer or Netscape Navigator) and electronic mail applications (e.g. Microsoft Outlook, and Lotus Notes) or other messaging applications to yield an operational GDMVC platform upon which an embodiment of the present invention may be implemented.

Accordingly, a novel method and apparatus is described for a method and

20 apparatus for graphical device management using a virtual console, so as to facilitate the rapid development of graphical user interfaces for remote device management. From the foregoing description, those skilled in the art will recognize that many other variations of the present invention are possible. In particular, while the present invention has been described as being implemented using particular

25 types of object-oriented classes, macros, and prototypes different types of classes, macros or programming languages could be employed without departing from the

principles of the present invention. In addition, some of the logic described in the processes illustrated in **Figures 2, 3, and 4**, may be distributed across various components of a general-purpose computer system **500** illustrated in **Figure 5** without departing from the principles of the present invention. Thus, the present
5 invention is not limited by the details described. Instead, the present invention can be practiced with modifications and alterations within the spirit and scope of the appended claims.
